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5/4/89

MAY 1, 1989
CHEMICAL & ENGINEERING

NEWS

More scientific news from Dallas meeting

Top 100 Chemical Producers

Page 11

CHEMICAL & ENGINEERING NEWS

Volume 67, Number 18
CENEAR 67 (18) 1–84
ISSN 0009-2347

MAY 1, 1989

News of the Week

■ **While skepticism may be growing among scientists over claims of cold fusion, Congress is anxious to know what the federal government can do to speed progress in the area.** **Page 6**

■ **Bigeye binary chemical bomb is panned by panel of experts formed by Comptroller General at the request of the Pentagon.** **Page 7**

■ **How to proceed on mapping the human genome is an open question, despite broad agreement that the project should proceed.** **Page 7**

■ **U.S. delegates in Helsinki this week at international meeting on protecting the ozone layer are pushing to add carbon tetrachloride and methyl chloroform to list of compounds regulated under the Montreal protocol.** **Page 8**

■ **Hoffmann-La Roche restructures its complex share-ownership structure to make shares more tradeable and bring the firm in line with new Swiss legislation.** **Page 9**

■ **National Academy of Sciences elects 60 new members, a number of them chemists.** **Page 9**

Letters 4
Editor's Page 5

Concentrates
Business 17
Government 21
Science/Technology 26

The Departments
New Products 46
Books 57
People 65
Meetings 66
Newscripts 84

Business

Mobay introduces new nylon engineering resins, Monsanto and Toray Industries form joint venture, as producers of these resins gear up to meet growing market; Koch Industries will provide $30 million of equity funding for joint technology venture with Catalytica. **Page 19**

Government

Budget matters, environmental issues have occupied much of the 101st Congress' attention in its first three months; as the effect of Alaska's huge oil spill continues to expand, public doubts are growing over the handling of the accident by Exxon and government agencies. **Page 22**

Science/Technology

Efforts to improve researcher access to biotechnology information sources increase; modifying electrodes using organized monomolecular assemblies allows for higher selectivity; new computational chemistry systems extend current capability in a number of areas. **Page 27**

Education

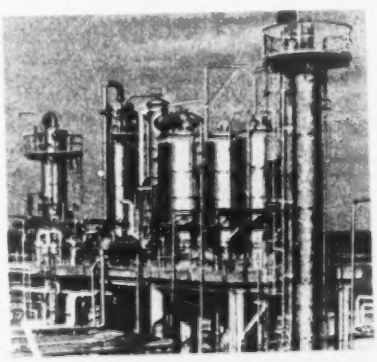
Committee on Professional Training reviews new biochemistry, education, and polymer options for undergraduate chemistry programs. **Page 49**

Priestley Medal Address

George Pimentel calls for chemists to take an active role in a campaign of public education on the benefits and risks of chemicals. **Page 53**

ACS News

Council voted for no increase in membership dues for next year at the national meeting in Dallas last month. **Page 62**



Top 100

Combined sales of the 100 largest U.S. chemical producers in 1988 were up nearly 18% from the previous year to a record $171 billion, reflecting the industry's continuing good health. **Page 11**

Chemical & Engineering News

1155—16th St., N.W., Washington, D.C. 20036

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Published by
AMERICAN CHEMICAL SOCIETY
(202) 872-4600, TDD (202) 872-8733
John K. Crum, Executive Director

PUBLISHING BOARD: Jean'ne M. Shreeve (*Chairman*); *Board of Directors Chairman*. Ernest L. Eliel; *President*. Clayton F. Callis, William P. Jencks, Gary J. Long, John H. Nelson, and Louis D. Quin

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Subscription Rates 1989. Printed editions: nonmembers U.S. 1 yr. $55, 2 yr. $99, outside U.S. 1 yr. $86, 2 yr. $161. Air freight rates available on request. Rates above do not apply to nonmember subscribers in Japan, who must enter subscription orders with Maruzen Co. Ltd., 3-10 Nihonbashi 2-chome, Chuo-ku, Tokyo 103, Japan. Tel: (03) 272-7211. Single copies: Current $7.00. Rates for back issues and volumes are available from Microforms & Back Issues Office, ACS, 1155—16th St., N.W., Washington, D.C. 20036. Back and current issues available on microfilm and microfiche. Rates on request from Microform Program, ACS.

Chemical & Engineering News (ISSN 0009-2347) is published weekly except for the last week in December by the American Chemical Society at 1155—16th St., N.W., Washington, D.C. 20036. Second-class postage paid at Washington, D.C., and additional mailing offices. POSTMASTER: Send address changes to Chemical & Engineering News, Membership & Subscription Services, P.O. Box 3337, Columbus, Ohio 43210. ACS assumes no responsibility for the statements and opinions advanced by the contributors to its publications.

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LETTERS

Neutral hydrolysis of peptide

SIR: I would like to draw attention to an important application of the hydrolysis rate of a peptide, PhePhePheGly, measured by D. Kahne and W. C. Still [*J. Am. Chem. Soc.*, **110**, 7529 (1988), and C&EN, Nov. 7, 1988, page 17]. The first-order rate constant at neutral pH and 25 °C is $k_h = 3 \times 10^{-9}\ s^{-1}$, which translates into a second-order rate constant of $k_{HOH}\ 10^{-10}\ M^{-1}\ s^{-1}$ for the uncatalyzed hydrolysis of peptides. This data can serve as a reference point not only for the efficiency of enzyme mimics but also for the efficiency of the enzymes that catalyze the decomposition of peptides (any other point of reference may be just as arguable).

Although serine protease-catalyzed reactions may have some different features, evolved precisely to accomplish the observed efficiency, from the nonenzymatic hydrolysis of their substrates, the rate acceleration with respect to the uncatalyzed hydrolytic reaction would include all components of catalysis enzymes evolved to employ. If serine proteases do or ever will catalyze the hydrolysis of their natural peptide substrates at the rate of diffusion ($k_b\ 10^9\ M^{-1}\ s^{-1}$), at the "speed limit," these then involve rate accelerations of 10^{19}—a surprising feat.

Actually, there must be some serine proteases, likely to be thrombin, that react with their natural substrates at nearly the diffusional rate. One may infer this from our recent use of chromogenic anilide substrates (Hemker, H. C., editor, "Handbook of Synthetic Substrates," page 70, Martinus Nijhoff Publisher, 1983) that are quite inert themselves (k_{HOH} is very likely to be $<10^{-9}\ M^{-1}\ s^{-1}$), but some of which hydrolyze at rates $k_c/K_m\ 10^6$ to $10^8\ M^{-1}\ s^{-1}$ with the serine protease they select for. Efficient catalysis of extended peptide substrates by serine proteases is associated with K_m values 10^{-7} to 10^{-5} M and $K_c < 300\ s^{-1}$.

In the case of inert compounds, leaving group departure often poses the greatest difficulty to overcome and may have to be the first chemical step for an enzyme to optimize. It certainly is not the rate-limiting step for acetylcholinesterase (another group of serine hydrolase enzymes) catalyzed hydrolysis of acetylcholine [Kovach, I. M., *J. Enzyme Inhibit.*, **2**, 198 (1988)] and may not be for serine protease hydrolysis of natural substrates either. Acetylcholinesterase seems to have gone beyond this point by optimizing all chemical steps in its reaction with its natural substrate, which may not yet be the case with serine proteases.

Notably, artificial enzyme mimic research is focused mostly on acceleration of the initial steps of enzymatic catalysis. Without the efficient removal of a leaving group, however, a correct assessment of the efficiency of the first steps is not possible. It is tempting to speculate that nature had to provide efficient catalysis for leaving-group departure early in the evolutionary process before optimizing other chemical steps.

Ildiko M. Kovach
Codirector, Biochemical Research Services Laboratory
Smissman Research Laboratories
Lawrence, Kan.

Nuclear power

SIR: I certainly agree with Claude Hudgens (C&EN, March 6, page 2) that nuclear energy is a viable and needed energy source. However, he unfortunately resorts to the same descriptive excesses regarding coal that he quite correctly decries about nuclear. Statements such as "strip mining damage is forever" and "coal is a dangerously polluting energy source" are just as inflammatory and untrue as "waste will remain dangerously radioactive for N-thousand years" and

Continued on page 82

1988 ACS Annual Report

In the 1988 ACS Annual Report, which accompanied the April 17 issue of C&EN, the names of two directors-at-large—Joe A. Adamcik and Stanley Kirschner—were inadvertently omitted. Kirschner was elected by mail ballot last April to serve the remainder of the 1987–89 term vacated by Adamcik, who resigned effective May 1, 1988. The editors of the Annual Report regret the error and any resulting confusion. Also, the number of documents cited by Chemical Abstracts Service in 1988 was 578,128, not 474,545.

Top 100 Chemical Producers Post Record Sales

Combined sales of 100 largest firms totaled $171 billion in 1988, up almost 18% from previous year; sales declined for only five of the 100

William J. Storck,
C&EN Northeast News Bureau

Another healthy year for the chemical industry in 1988 is reflected in C&EN's annual compilation of financial results for the 100 largest chemical producers in the U.S. The year created, by far, the biggest Top 100 chemical producers in terms of sales. However, as in the past, continuing restructuring in the industry has brought about change in the companies listed and in the rankings among the companies from the previous year's rank. And, over the past few years, this restructuring has caused major changes in the types of companies producing chemicals.

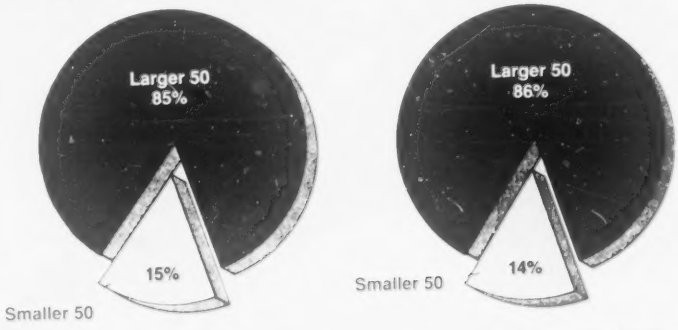
The biggest change for the Top 100 is in the sales that the companies posted in 1988. Total sales for the 100 producers amounted to $171 billion, up almost 18% from that of the 100 companies listed in 1987. And the 1988 sales figure was up about 20% from what the companies listed in 1988 achieved in 1987. Sales growth for the firms listed in 1988 averaged 21% for the 50 larger companies, but just 14% for 48 of the smaller 50 companies for which comparable figures are available.

Sales declined for only five of the 100 companies, the fewest in recent memory, and for one of these, International Minerals & Chemical, the decline occurred because IMC spun off its fertilizer operations into IMC Fertilizer. For two of the companies—Borden Chemicals & Plastics and Sherex, 1987 sales figures were unavailable; therefore, growth could not be measured. Thus, 93 of the companies posted increases in sales in 1988 over 1987.

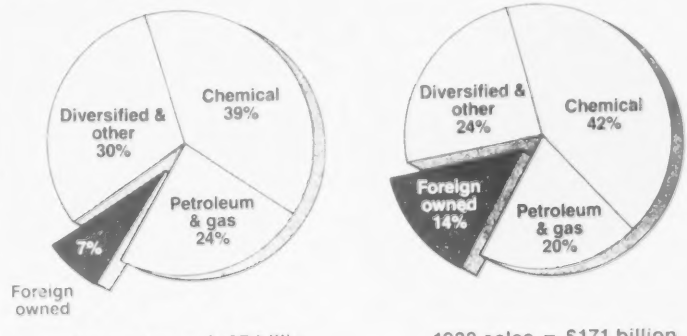
The ranking of the Top 100 producers is based on chemical sales information from annual reports and, in the case of companies not issuing annual reports, other published data or interviews with the firms.

For the third year in a row, the top five chemical producers—Du Pont, Dow Chemical, Exxon, Union Carbide, and Monsanto—held their ranking, with Du Pont the top chemical producer. Although technically classified as a diversified company because of its large sales volume in oil and other areas, Du Pont's an-

Chemical sales split between large and small firms has changed little since 1984...



...but foreign-owned companies have doubled their share of chemical sales



Note

Chemical sales, operating profits increased dramatically for most producers

Rank 1988	Rank 1987		Chemical sales 1988 ($ millions)	Change from 1987	Chemical sales as % of total sales	Industry classification	Chemical operating profits[a] ($ millions)	Change from 1987	Chemical operating profits as % of total	Operating profit margin[b]	Identifiable chemical assets ($ millions)	Chemical assets as % of total assets	Operating return on chemical assets[c]
1	1	Du Pont	$14,717	12.8%	44.7%	Diversified	$2612	12.9%	61.3%	17.7%	$10,290	38.3%	25.4%
2	2	Dow Chemical	12,128	11.8	72.7	Basic chemicals	3655	89.4	88.0	30.1	10,792	66.5	33.9
3	3	Exxon	9,990	39.2	11.4	Petroleum	1863	71.4	21.2	18.6	6,731	9.1	27.7
4	4	Union Carbide	7,601[d]	23.1	91.3	Basic chemicals	1542	76.8	96.0	20.3	6,897	88.3	22.4
5	5	Monsanto	5,535	7.2	66.7	Basic chemicals	910	18.8	95.3	16.4	4,144	49.0	22.0
6	6	Hoechst Celanese	5,369	25.3	94.5	Basic chemicals	563	26.8	102.4	10.5	na	na	na
7	10	Occidental Petroleum	4,673	56.2	23.4	Petroleum	1050	163.8	191.6	22.5	5,258	25.3	20.0
8	7	BASF	4,536	18.9	88.0	Basic chemicals	na	na	na	na	na	na	na
9	9	Amoco	4,352	24.6	18.2	Petroleum	1022	45.2	28.1	23.5	2,920	9.9	35.0
10	11	Mobil	4,280	46.3	7.9	Petroleum	851	96.5	19.4	19.9	2,802	7.7	30.4
11	8	Shell Oil	4,006	12.0	19.0	Petroleum	746	24.3	34.1	18.6	3,822	14.1	19.5
12	14	General Electric	3,539[d]	28.6	7.1	Diversified	733	44.6	12.3	20.7	7,130	6.4	10.3
13	16	Chevron	3,204	23.6	11.6	Petroleum	616	55.2	19.0	19.2	2,101	6.7	29.3
14	13	W. R. Grace	3,131	12.1	54.1	Specialty chemicals	388	8.7	65.2	12.4	2,204	48.4	17.6
15	15	Eastman Kodak	3,033	16.7	17.8	Photo equipment	628	61.9	21.4	20.7	2,875	12.5	21.8
16	12	Allied-Signal	3,033	8.5	25.5	Diversified	377	23.2	53.6	12.4	1,839	18.4	20.5
17	19	Arco Chemical	2,700	38.3	100.0	Basic chemicals	722	81.4	100.0	26.7	2,548	100.0	28.3
18	17	Rohm & Haas	2,535	15.1	100.0	Basic chemicals	377	16.7	100.0	14.9	1,857	100.0	20.3
19	21	Phillips Petroleum	2,518	30.6	22.3	Petroleum	911	89.0	46.3	36.2	1,349	11.3	67.5
20	22	Air Products*	2,237	16.6	92.0	Basic chemicals	409	9.8	108.7	18.3	2,462	87.1	16.6
21	23	Quantum Chemical	2,219	18.3	76.0	Basic chemicals	711	104.7	93.6	32.1	1,465	50.4	48.6
22	18	American Cyanamid	2,167	10.5	47.2	Basic chemicals	214	11.0	38.9	9.9	1,519	49.4	14.1
23	20	Bayer USA	2,140	9.7	45.4	Diversified chemicals	118[f]	40.5	94.9	5.5	na	na	na
24	26	Ashland Oil*	2,090	27.2	25.5	Petroleum	102	13.3	24.7	4.9	754	17.7	13.5
25	25	B. F. Goodrich	2,074	19.1	85.8	Basic chemicals	308	46.5	88.5	14.8	1,358	79.9	22.7
26	32	Atlantic Richfield	1,903	38.0	10.4	Petroleum	na	na	na	na	na	na	na
27	26	Hercules	1,750	3.8	62.5	Basic chemicals	141	5.2	91.0	8.1	1,376	62.2	10.2
28	29	Texaco	1,711	7.8	5.1	Petroleum	379	193.8	11.8	22.2	1,029	3.9	36.8
28	—	Himont	1,711	46.8	100.0	Basic chemicals	526	69.1	100.0	30.7	1,044	100.0	50.3
30	31	Ethyl	1,674	19.1	61.6	Basic chemicals	309	20.1	70.4	18.5	1,141	22.7	27.1
31	43	BP America	1,507	59.8	9.8	Petroleum	na	na	na	na	na	na	na
32	33	Dow Corning	1,477	13.3	100.0	Specialty chemicals	151[f]	11.5	100.0	10.2	na	na	na
33	30	FMC	1,435	−3.6	43.7	Machinery	224	−7.7	58.4	15.6	1,234	54.1	18.1
34	37	National Starch	1,415	17.1	100.0	Specialty chemicals	200	14.1	100.0	14.1	1,110	100.0	18.0
35	34	Rhône-Poulenc	1,400	7.7	100.0	Specialty chemicals	na	na	na	na	na	na	na
36	35	Olin	1,366	10.9	59.2	Basic chemicals	105	6.1	58.3	7.7	953	49.1	11.0
37	40	Akzo	1,347	35.8	100.0	Basic chemicals	76	78.8	100.0	5.6	na	na	na
38	41	Aluminum Co. of America	1,215[g]	23.7	12.4	Nonferrous metals	419	569.2	24.1	34.5	2,577	24.5	16.3
39	38	Unocal	1,204	12.4	11.9	Petroleum	182	574.1	39.9	15.1	622	6.5	29.3
40	39	Huntsman Chemical	1,200	17.4	100.0	Basic chemicals	na	na	na	na	na	na	na
41	46	Freeport-McMoRan	1,130	31.5	58.1	Agrochemicals	198	85.9	39.3	17.5	894	24.0	22.1
42	42	PPG Industries	1,113	16.8	19.8	Glass Products	255	82.1	27.6	22.9	1,048	20.3	24.3
43	28	Ciba-Geigy	1,098[g]	15.7	32.5	Specialty chemicals	na	na	na	na	na	na	na
44	—	IMC Fertilizer[h]	1,086	23.9	100.0	Agrochemicals	219	364.1	100.0	20.1	1,472	100.0	14.8
45	45	Aristech	1,065	15.9	100.0	Basic chemicals	196	63.2	100.0	18.4	676	100.0	29.0
46	58	Georgia Gulf	1,061	49.9	100.0	Basic chemicals	312	92.0	100.0	29.4	457	100.0	68.3
47	44	Lubrizol	1,036	10.2	92.0	Specialty chemicals	306	119.5	91.6	29.6	730	75.3	41.9
48	48	Pennwalt	1,024	21.0	100.0	Basic chemicals	135	31.5	100.0	13.2	738	100.0	18.3
49	47	NL Industries	1,007	17.2	100.0	Basic chemicals	261	24.8	100.0	25.9	841	100.0	31.0
50	59	Solvay America	1,000[d]	17.6	100.0	Basic chemicals	na	na	na	na	na	na	na

Rank 1988	Rank 1987		Chemical sales 1988 ($ millions)	Change from 1987	Chemical sales as % of total sales	Industry classification	Chemical operating profits[a] ($ millions)	Change from 1987	Chemical operating profits as % of total	Operating profit margin[b]	Identifiable chemical assets ($ millions)	Chemical assets as % of total assets	Operating return on chemical assets[c]
51	49	Nalco Chemical	$994	18.1%	100.0%	Specialty chemicals	$159	21.2%	100.0%	16.0%	$ 839	100.0%	18.9%
52	51	CF Industries	958	18.3	100.0	Agrochemicals	110	2461.4	100.0	11.5	991	100.0	11.1
53	36	International Minerals[h]	932	−23.2	100.0	Specialty chemicals	117	12.9	100.0	12.5	1,050	100.0	11.1
54	52	Cabot[e]	904	13.0	53.9	Basic chemicals	163	33.4	121.4	18.0	665	43.1	24.5
55	55	Morton Thiokol[h]	874	17.4	37.7	Diversified	149	14.7	52.2	17.0	795	41.4	18.7
56	60	Terra Chemicals	849	25.0	100.0	Agrochemicals	na	na	na	na	na	na	na
57	54	International Flavors	840	12.6	100.0	Specialty chemicals	209	14.0	100.0	24.9	882	100.0	23.7
58	53	Eli Lilly	798	6.6	19.6	Drugs	126	48.9	11.3	15.8	787	15.0	16.1
59	64	Vista Chemicals[e]	781	28.3	100.0	Basic chemicals	195	63.3	100.0	24.9	521	100.0	37.4
60	68	Farmland Industries	767	46.2	27.3	Agricultural supplies	75	5838.7	66.7	9.8	324	44.5	23.1
61	63	Witco	758[g]	21.5	47.8	Specialty chemicals	62	2.2	43.0	8.2	361	32.4	17.2
62	67	Uniroyal Chemical	734	24.3	100.0	Specialty chemicals	86	17.2	100.0	11.7	1,016	100.0	8.5
63	57	Engelhard	727	2.0	30.9	Specialty metals	107	22.7	85.5	14.8	880	62.3	12.2
64	—	Sterling Chemical	699	69.2	100.0	Basic chemicals	312	246.4	100.0	44.7	294	100.0	106.1
65	66	H. B. Fuller[i]	685	14.7	100.0	Specialty chemicals	46	−2.8	100.0	6.8	421	100.0	11.0
66	61	American Petrofina	682	1.7	27.7	Petroleum	281	38.2	113.7	41.1	360	15.5	77.9
67	65	Henkel	650	8.3	100.0	Specialty chemicals	na	na	na	na	na	na	na
68	72	Great Lakes Chemical	558	16.6	100.0	Specialty chemicals	143	68.7	100.0	25.7	664	100.0	21.6
69	—	Borden Chemicals	553	na	100.0	Basic chemicals	121	−41.8	100.0	21.9	605	100.0	20.0
70	76	GAF	545	26.3	56.7	Specialty chemicals	150	15.4	83.2	27.5	na	na	na
71	73	Kerr-McGee	518	11.6	19.3	Petroleum	102	43.7	43.8	19.7	671	22.3	15.2
72	69	Pfizer	512	−0.2	9.5	Drugs	49	−29.7	4.4	9.5	489	6.4	10.0
73	75	Tyler	485	11.3	75.3	Diversified	37	1.3	85.0	7.6	202	65.7	18.3
74	76	Merck	466	8.1	7.8	Drugs	62	6.6	3.3	13.2	426	7.0	14.4
75	79	Sun Co.	461	24.4	4.7	Petroleum	na	na	na	na	na	na	na
76	—	Hoffmann-La Roche	450	4.2	23.7	Drugs	na	na	na	na	na	na	na
77	78	Betz Laboratories	448	16.0	100.0	Specialty chemicals	na	na	na	na	na	na	na
78	80	Ferro	443	22.3	43.9	Specialty materials	18	−34.8	17.7	4.1	242	45.8	7.5
79	88	Dexter	424	9.7	51.3	Rubber products	26	−28.1	28.3	6.1	298	47.6	8.7
80	83	Loctite	417	23.4	100.0	Specialty chemicals	66	45.1	100.0	15.8	347	100.0	19.0
81	82	Union Camp	398	14.3	15.0	Diversified	30	42.8	6.0	7.5	294	9.5	10.2
82	85	Lonza	395	26.6	100.0	Specialty chemicals	na	na	na	na	na	na	na
83	86	Vulcan Materials	383	28.5	36.3	Nonmetallic minerals	66	102.3	31.9	17.3	na	na	na
84	87	Stepan	333	15.3	100.0	Specialty chemicals	21	6.9	100.0	6.2	186	100.0	11.1
85	90	Sigma-Aldrich	302	22.1	80.5	Specialty chemicals	77	20.7	86.9	25.5	314	87.4	24.5
86	89	Petrolite[j]	274	10.4	91.0	Specialty chemicals	21	−1.2	127.5	7.7	186	76.7	11.4
87	84	Chemed	270	−19.6	54.0	Specialty chemicals	33	−19.0	66.6	12.4	133	48.3	25.1
88	94	Georgia-Pacific	241	27.5	2.5	Wood products	na	na	na	na	na	na	na
89	95	First Mississippi	237	31.2	74.6	Agrochemicals	23	190.0	101.4	9.8	104	34.6	22.3
90	92	Crompton & Knowles	232	21.8	80.2	Specialty chemicals	26	33.5	71.3	11.4	159	77.1	16.7
91	—	Calgon Carbon	226	32.5	100.0	Basic chemicals	51	30.6	100.0	22.6	196	100.0	26.1
92	—	Sherex	200	na	100.0	Specialty chemicals	na	na	na	na	na	na	na
93	96	Mississippi Chemical	186	6.6	100.0	Farm cooperative	18	def	100.0	9.8	322	100.0	5.7
94	97	Quaker Chemical	167	12.9	100.0	Specialty chemicals	17	3.5	100.0	10.4	121	100.0	14.3
95	99	LeaRonal[k]	157	23.0	100.0	Specialty chemicals	14	12.4	100.0	9.0	88	100.0	15.9
96	—	Lawter International	126	12.3	100.0	Specialty chemicals	27	11.5	100.0	21.8	125	100.0	21.9
97	100	UGI	124	6.7	28.5	Natural gas	4	200.8	6.9	3.6	168	27.2	2.6
98	98	Agway	123	−7.6	3.4	Farm cooperative	na	na	na	na	na	na	na
99	—	Cambrex	120	11.5	100.0	Specialty chemicals	13	−4.3	100.0	10.5	na	na	na
100	—	Products Research	100	5.4	100.0	Specialty chemicals	17	−11.7	100.0	16.6	68	100.0	24.6

a Operating profit is sales less administrative expenses and costs of sales. b Operating profit from chemicals as a percentage of sales. c Chemical operating profit as a percentage of identifiable chemical assets. d Chemical sales include significant amounts of nonchemical products. e Fiscal year ends Sept. 30. f Chemical net income. g Does not include all chemical sales. h Fiscal year ends June. 30. i Fiscal year ends Nov. 30. j Fiscal year ends Oct. 31. k For fiscal year ended Feb. 29, 1988. na = not available.

C&EN's five-way ranking of the Top 100 chemical producers

$ Millions	Chemical sales 1988	Rank 1988	Rank 1987	Chemical operating profits 1988	Rank 1988	Rank 1987	Chemical operating profit margin 1988	Rank 1988	Rank 1987	Identifiable chemical assets 1988	Rank 1988	Rank 1987	Return on chemical assets 1988	Rank 1988	Rank 1987
Agway	$ 123	98	98	na	—	—	na	—	—	na	—	—	na	—	—
Air Products	2,237	20	22	$ 409	19	16	18.3%	35	12	$2,462	14	14	16.6%	52	37
Akzo	1,347	37	40	76	58	—	5.6	80	—	na	—	—	na	—	—
Allied-Signal	3,033	15	12	377	22	20	12.4	55	55	1,839	18	15	20.5	37	43
Aluminum Co. of America	1,215	38	41	419	18	56	34.5	4	71	2,577	12	12	16.3	53	71
American Cyanamid	2,167	22	19	214	34	27	9.9	65	58	1,519	19	22	14.1	60	53
American Petrofina	682	66	61	281	29	26	41.1	2	2	360	57	61	77.9	2	1
Amoco	4,352	9	9	1022	6	6	23.5	17	10	2,920	9	8	35.0	10	8
Arco Chemical	2,700	17	19	722	12	11	26.7	11	9	2,548	13	29	28.3	17	14
Aristech	1,065	45	45	196	38	39	18.4	34	44	676	45	—	29.0	16	—
Ashland Oil	2,090	24	27	102	54	46	4.9	81	73	754	42	46	13.5	61	44
Atlantic Richfield	1,903	26	32	na	—	—	na	—	—	na	—	—	na	—	—
BASF	4,536	8	7	na	—	—	na	—	—	na	—	—	na	—	—
BP America	1,507	31	43	na	—	65	na	—	76	na	—	—	na	—	—
Bayer USA	2,140	23	20	na	—	—	na	—	—	na	—	—	na	—	—
Betz Laboratories	448	77	78	na	—	53	na	—	20	na	—	60	na	—	12
Borden Chemicals	553	69	—	121	49	—	21.9	22	—	605	50	—	20.0	39	—
CF Industries	958	52	51	110	51	78	11.5	59	79	991	33	33	11.1	64	73
Cabot	904	54	52	163	41	38	18.0	36	25	665	47	48	24.5	24	17
Calgon Carbon	226	91	—	51	64	—	22.6	19	—	196	67	—	26.1	20	—
Cambrex	120	99	—	13	81	—	10.5	61	—	na	—	—	na	—	—
Chemed	270	87	84	33	68	61	12.4	57	47	133	72	69	25.1	22	14
Chevron	3,204	13	16	616	15	13	19.2	30	25	2,101	16	18	29.3	14	15
Ciba-Geigy	1,098	43	28	na	—	—	na	—	—	na	—	—	na	—	—
Crompton & Knowles	232	90	92	26	71	73	11.4	60	56	159	71	73	16.7	51	21
Dexter	424	79	88	26	72	67	6.1	79	57	298	62	67	8.7	73	37
Dow Chemical	12,128	2	2	3655	1	2	30.1	7	17	10,792	1	1	33.9	11	19
Dow Corning	1,477	32	33	na	—	—	na	—	—	na	—	—	na	—	—
Du Pont	14,717	1	1	2612	2	1	17.7	37	19	10,290	2	2	25.4	21	11
Eastman Kodak	3,033	15	15	628	14	14	20.7	25	29	2,875	10	9	21.8	35	40
Eli Lilly	798	58	53	126	48	48	15.8	44	52	787	41	36	16.1	54	60
Engelhard	727	63	57	107	52	47	14.8	50	47	880	37	40	12.2	62	57
Ethyl	1,674	30	31	309	26	21	18.5	33	16	1,141	26	30	27.1	19	10
Exxon	9,990	3	3	1863	3	3	18.6	31	28	6,731	5	3	27.7	18	33
FMC	1,435	33	30	224	32	22	15.6	46	23	1,234	25	23	18.1	47	30
Farmland Industries	767	60	68	75	59	79	9.8	68	80	324	59	57	23.1	28	74
Ferro	443	78	80	18	76	68	4.1	82	69	242	65	66	7.5	75	44
First Mississippi	237	89	95	23	73	77	9.8	67	75	104	75	74	22.3	31	67
Freeport-McMoRan	1,130	41	46	198	37	42	17.5	38	46	894	35	38	22.1	32	44
H. B. Fuller	685	65	66	46	66	59	6.8	77	66	421	55	56	11.0	67	48
GAF	545	70	76	150	43	35	27.5	10	3	na	—	53	na	—	5
General Electric	3,539	12	14	733	11	8	20.7	24	15	7,130	3	6	10.3	69	56
Georgia Gulf	1,061	46	58	312	24	30	29.4	9	8	457	53	58	68.3	3	3
Georgia-Pacific	241	88	94	na	—	—	na	—	—	na	—	—	na	—	—
B. F. Goodrich	2,074	25	25	308	27	23	14.8	49	50	1,358	23	25	22.7	29	35
W. R. Grace	3,131	14	13	388	20	17	12.4	56	45	2,204	15	16	17.6	49	28
Great Lakes Chemical	558	68	72	143	45	48	25.7	13	17	664	48	47	21.6	36	47
Henkel	650	67	65	na	—	—	na	—	—	na	—	—	na	—	—
Hercules	1,750	27	26	141	46	33	8.1	72	68	1,376	22	24	10.2	70	66
Himont	1,711	28	—	524	17	—	30.7	6	—	1,044	30	—	36.8	8	—

$ Millions	Chemical sales	Rank		Chemical operating profits	Rank		Chemical operating profit margin	Rank		Identifiable chemical assets	Rank		Return on chemical assets	Rank	
	1988	1988	1987	1988	1988	1987	1988	1988	1987	1988	1988	1987	1988	1988	1987
Hoechst Celanese	$5,369	6	6	$ 563	16	—	10.5%	62	—	na	—	—	na	—	—
Hoffmann-La Roche	450	76	—	na	—	—	na	—	—	na	—	—	na	—	—
Huntsman Chemical	1,200	40	39	na	—	—	na	—	—	na	—	—	na	—	—
IMC Fertilizer	1,086	44	—	219	33	—	20.1	27	—	$1,472	20	—	14.8%	57	—
International Flavors	840	57	54	209	35	28	24.9	15	6	882	36	41	23.7	27	7
International Minerals	932	53	36	117	50	43	12.5	54	62	1,050	28	17	11.1	64	69
Kerr-McGee	518	71	73	102	54	50	19.7	29	25	671	46	49	15.2	56	57
Lawter International	126	96	—	27	70	—	21.8	23	—	125	73	—	21.9	34	—
LeaRonal	157	95	99	14	80	76	9.0	70	58	88	76	75	15.9	55	34
Loctite	417	80	83	66	60	60	15.8	45	41	347	58	59	19.0	42	41
Lonza	395	82	85	na	—	—	na	—	—	na	—	—	na	—	—
Lubrizol	1,036	47	44	306	28	31	29.6	8	30	730	44	42	41.9	6	18
Merck	466	74	76	62	62	58	13.2	53	41	426	54	52	14.4	58	55
Mississippi Chemical	186	93	96	18	76	81	9.8	66	—	322	60	64	5.7	76	—
Mobil	4,280	10	11	851	9	10	19.9	28	30	2,802	11	13	30.4	13	24
Monsanto	5,535	5	5	910	8	5	16.4	42	30	4,144	7	5	22.0	33	23
Morton Thiokol	874	55	55	149	44	35	17.0	40	21	795	40	39	13.7	44	25
NL Industries	1,007	49	47	261	30	24	25.9	12	7	841	38	35	31.0	12	6
Nalco Chemical	994	51	49	159	42	34	16.0	43	24	839	39	34	18.9	43	32
National Starch	1,415	34	37	200	36	29	14.1	51	35	1,110	27	31	18.0	48	25
Occidental Petroleum	4,673	7	10	1050	5	11	22.5	20	43	5,258	6	11	20.0	39	37
Olin	1,366	36	35	105	53	45	7.7	74	66	953	34	32	11.0	67	64
PPG Industries	1,113	42	42	255	31	31	22.9	18	33	1,048	29	29	24.3	26	54
Pennwalt	1,024	48	48	135	47	44	13.2	52	49	738	43	37	18.3	45	49
Petrolite	274	86	89	21	74	71	7.7	73	61	186	68	68	11.4	63	59
Pfizer	512	72	69	49	65	51	9.5	69	39	489	52	51	10.0	72	49
Phillips Petroleum	2,518	19	21	911	7	9	36.2	3	5	1,349	24	27	67.5	4	4
Products Research	100	100	—	17	78	—	16.6	41	—	68	77	—	24.6	23	—
Quaker Chemical	167	94	97	17	78	74	10.4	63	51	121	74	72	14.3	59	51
Quantum Chemical	2,219	21	23	711	13	18	32.1	5	14	1,465	21	21	48.6	5	13
Rhône-Poulenc	1,400	35	34	na	—	—	na	—	—	na	—	—	na	—	—
Rohm & Haas	2,535	18	17	377	22	19	14.9	48	33	1,857	17	20	20.3	38	20
Shell Oil	4,006	11	8	746	10	7	18.6	32	22	3,822	8	7	19.5	41	36
Sherex	200	92	—	na	—	—	na	—	—	na	—	—	na	—	—
Sigma-Aldrich	302	85	90	77	57	55	25.5	14	4	314	61	63	24.5	24	9
Solvay America	1,000	50	59	na	—	—	na	—	—	na	—	—	na	—	—
Stepan	333	84	87	21	74	40	6.2	78	1	186	68	70	11.1	64	2
Sterling Chemical	699	64	—	312	24	—	44.7	1	—	294	63	—	106.1	1	—
Sun Co.	461	75	79	na	—	—	na	—	—	na	—	—	na	—	—
Terra Chemicals	849	56	60	na	—	—	na	—	—	na	—	—	na	—	—
Texaco	1,711	28	29	379	21	37	22.2	21	65	1,029	31	26	36.8	8	63
Tyler	485	73	75	37	67	63	7.6	75	64	202	66	65	18.3	45	31
UGI	124	97	100	4	82	79	3.6	83	78	168	70	76	2.6	77	72
Union Camp	398	81	82	30	69	71	7.5	76	72	294	63	62	10.2	70	68
Union Carbide	7,601	4	4	1542	4	4	20.3	26	37	6,897	4	4	22.4	30	52
Uniroyal Chemical	734	62	—	86	56	—	11.7	58	—	1,016	32	—	8.5	74	—
Unocal	1,204	39	38	182	40	70	15.1	47	77	622	49	43	29.3	14	70
Vista Chemical	781	59	64	195	39	40	24.9	16	11	521	51	50	37.4	7	12
Vulcan Materials	383	83	86	66	60	64	17.3	39	54	na	—	—	na	—	—
Witco	758	61	63	62	62	57	8.2	71	60	361	56	55	17.2	50	28

Note: Companies giving only net profits are not ranked. There are 83 firms ranked for operating profits and operating profit margin and 77 firms ranked for chemical assets and return on assets. na = not available.

Companies new to Top 100 in 1988 . . .

	Sales rank 1988
Himont	28
IMC Fertilizer	44
Sterling Chemical	64
Borden Chemicals	69
Hoffmann-La Roche	76
Calgon Carbon	91
Sherex	92
Lawter International	96
Cambrex	99
Products Research	100

. . . and those no longer on list

	Sales rank 1987
Borden	24
Reichhold	50
Polysar	56
Koppers	62
Liquid Air	70
CBI Industries	71
Henley Manufacturing	73
Cain Chemical	81
Kaisertech	91
Essex Chemical	92

nual chemical sales totaled about $14.7 billion in 1988, about $2.6 billion more than sales at Dow Chemical, ranked second.

The sixth-ranked company in 1987, Hoechst Celanese, also appears in the same place in 1988, but after that there is a good deal of shifting. Seventh-ranked Occidental Petroleum moved up from 10th in 1987, causing BASF to drop to eighth. Ninth-ranked Amoco held the same place in both years, but 10th-ranked Mobil moved up from 11th in 1987's ranking. Eighth in 1987, Shell Oil fell all the way to 11th in 1988.

Of the companies that appeared on both the 1987 and 1988 lists, 49 moved up in the rankings, 27 declined in their rankings, and 14 held the same position. The biggest increases in rank were registered by BP America, which moved from 43rd in 1987 to 31th in 1988, and Georgia Gulf, which rose to 46th from 58th—both 12 places. BP America's rise is the result of the full consolidation this year of Standard Oil's business into BP. Georgia Gulf's rise stemmed primarily from improved business.

The two largest declines were recorded by Ciba-Geigy—15 places to 43rd from 28th—and by International Minerals—17 places to 53rd from 36th. The drop for Ciba-Geigy comes from a restructuring within the company and a revamping of its reporting methods. In 1988 not all of its chemicals sales are included, since its sales of pesticides are lumped with those of pharmaceuticals.

For IMC, as mentioned earlier, the drop in ranking resulted from the spinoff of IMC Fertilizer, which is new to the list in 1988 and ranked 44th. A similar situation occurred with Borden Chemicals & Plastics, also new on the list and ranked 69th. This firm was spun off from Borden, which disappears from the 1988 rankings.

Eight other firms are new to the 1988 rankings. Hoffmann-La Roche and Sherex, two foreign-owned firms that could have been included in the past, finally disclosed chemical sales for 1988. Himont can now be included because its results are no longer incorporated into Hercules (Himont's inclusion in previous listings would have resulted in double counting). And Sterling Chemical now makes its results public. The remaining four firms—Calgon Carbon, Lawter International, Cambrex Corp., and Products Research & Chemical—move onto the list because other companies have dropped off.

The restructuring of the chemical industry is readily apparent when 1988 results are compared with those of just a few years ago. In 1984, the first year with a comparable breakout, foreign-owned firms made up just 7% of total chemical sales of the Top 100 companies. By 1988, however this figure had grown to 13%. Firms classified as chemical companies—those with chemical sales making up more than 50% of total sales—also increased their percentage of the total, to 42% in 1988 from 39% of companies listed in 1984. Since petroleum and natural gas producing companies kept their percentage stable at about 24%, these increases came at the expense of firms classified as diversified and other, whose percentage fell to about 20% of the total for those companies listed in 1988 as opposed to 30% for the firms listed in 1984.

C&EN's rankings of the Top 100 includes measures other than sales. Companies are also ranked by chemical operating profits, chemical assets, and operating returns on sales and assets.

Growth in operating profits in 1988 for those firms reporting these figures averaged 54%. Among the larger 50 firms, growth in operating profits averaged 56%, far outperforming the 35% growth for the smaller 50 reporting these results.

The larger firms also outperformed the smaller in profitability. Operating profit margins among the larger 50 for which this can be calculated averaged 19% in 1988, up from 15% in the previous year. For these firms, the average operating profit margin was 17%, up from 14%. This gives an average for the group of 19%, up from 15%.

The same trend holds for return on chemical assets. Here the larger 50 firms averaged 25% in 1988, up from 19% in 1987. The smaller 50 companies averaged 19%, an increase from 15%. The average for the companies reporting both operating profits and chemical assets was 24%, up from 18%.

Although Du Pont is the sales leader among the Top 100, Dow Chemical is on top in both chemical operating profits and identifiable assets in 1988. Dow's $3.7 billion in chemical operating profits was more than $1 billion higher than Du Pont's operating profits and its identifiable chemical assets of $10.8 billion were about $500 million more than those of Du Pont.

Following Du Pont in operating profits were Exxon, Union Carbide, and Occidental Petroleum. And following it in chemical assets were General Electric, Carbide, and Exxon.

The leader in operating profit margin was Sterling Chemical at 45%. Sterling was followed by American Petrofina (41%), Phillips Petroleum (36%), Alcoa (35%), and Quantum Chemical (32%).

Sterling also was tops in operating return on assets with a phenomenal 106%, followed by American Petrofina (78%), Georgia Gulf and Phillips (68%), and Quantum (49%). □